



# Fermilab Test Beam Facility

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52nd Annual Fermilab Users Meeting

12 June 2019

# What is the Test Beam Facility?

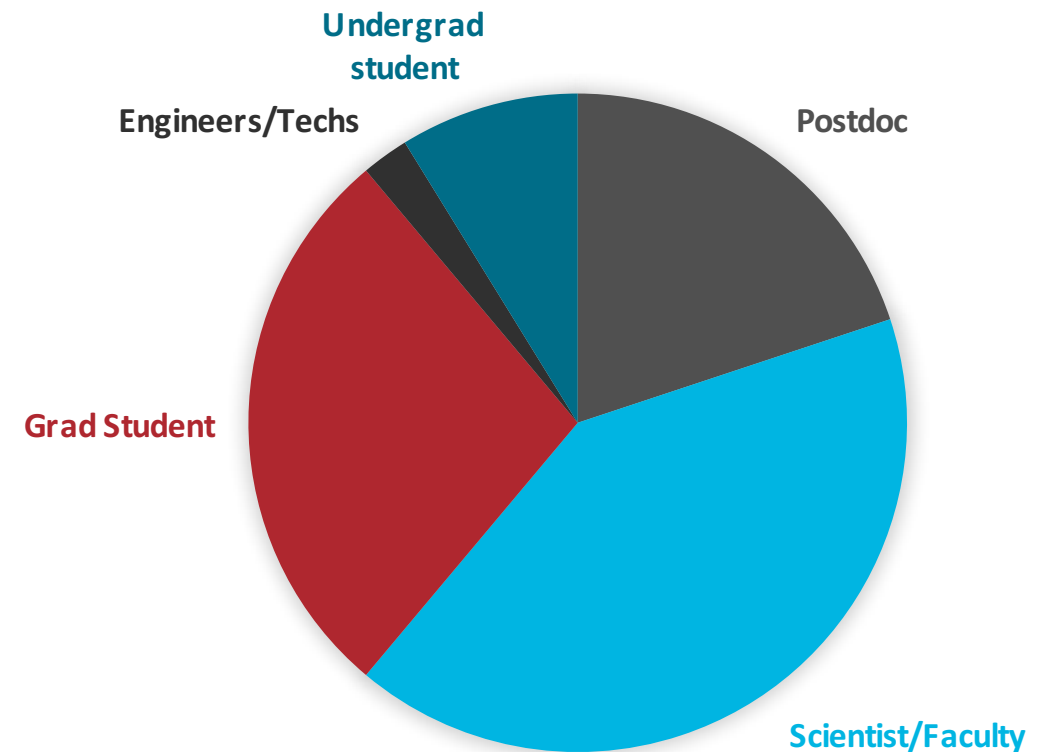
- Operating since 2005, served over 1000 users from 30 countries
- Broad program spanning collider, muon, neutrino, and general R&D
  - Flexible infrastructure to fit user needs
- Two beamlines with energies from 120 GeV primary protons down to ~200 MeV in the tertiary line
- Projects as small as one person. Rapid experiment changeover. Many repeat customers
- During the CERN LS2 shutdown FTBF is the only high energy test beam facility in the world



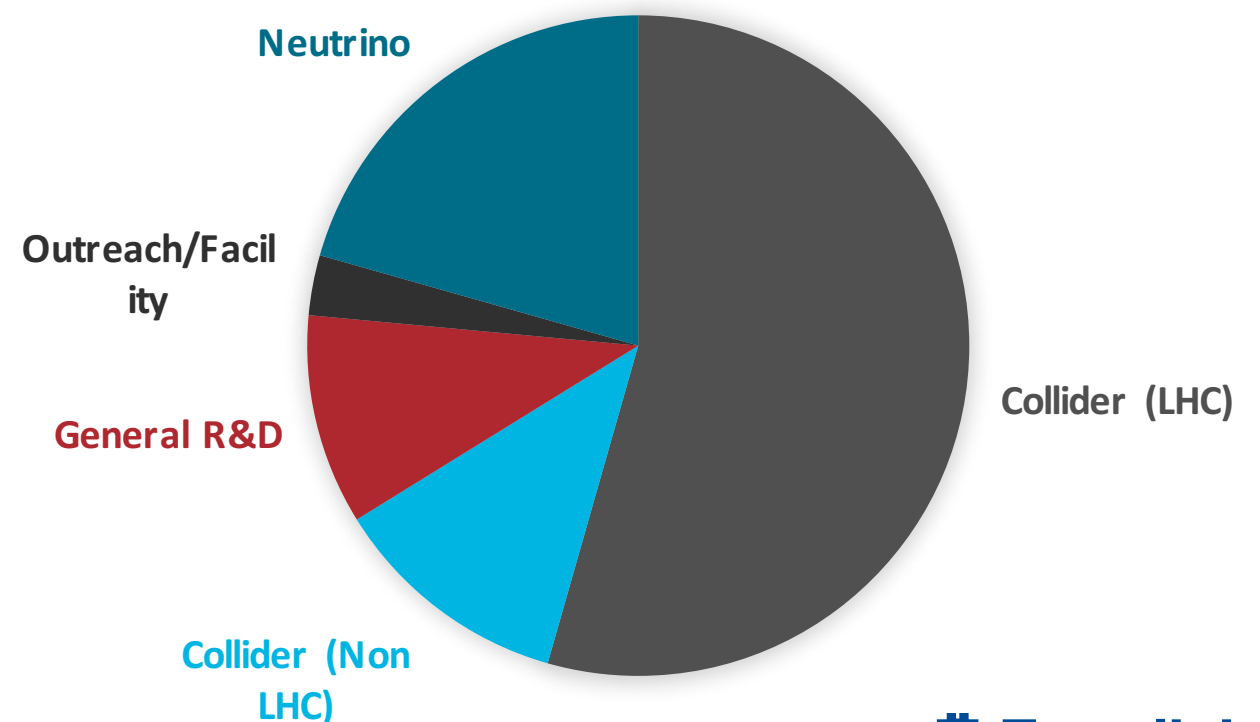
# Who?

- 264 users from 20 experiments in FY18 plus the EDIT school
- ~18 groups in FY19
- Three new efforts
  - T-1564 (LHCb)
  - T-1575 (Zero Degree Calorimeter)
  - NOvA test beam program
- Two theses in 2018-2019
  - Elena Gramellini, Yale: [\*Measurement of the Negative Pion and Positive Kaon Total Hadronic Cross Sections on Argon at the LAr\*](#)
  - William Foreman, U. Chicago: [\*A Demonstration of Light-Augmented Calorimetry For Low-Energy Electrons in Liquid Argon\*](#)

FY18 USERS BY JOB TYPE



FY18 USER GROUP BY RESEARCH FOCUS





# Where?

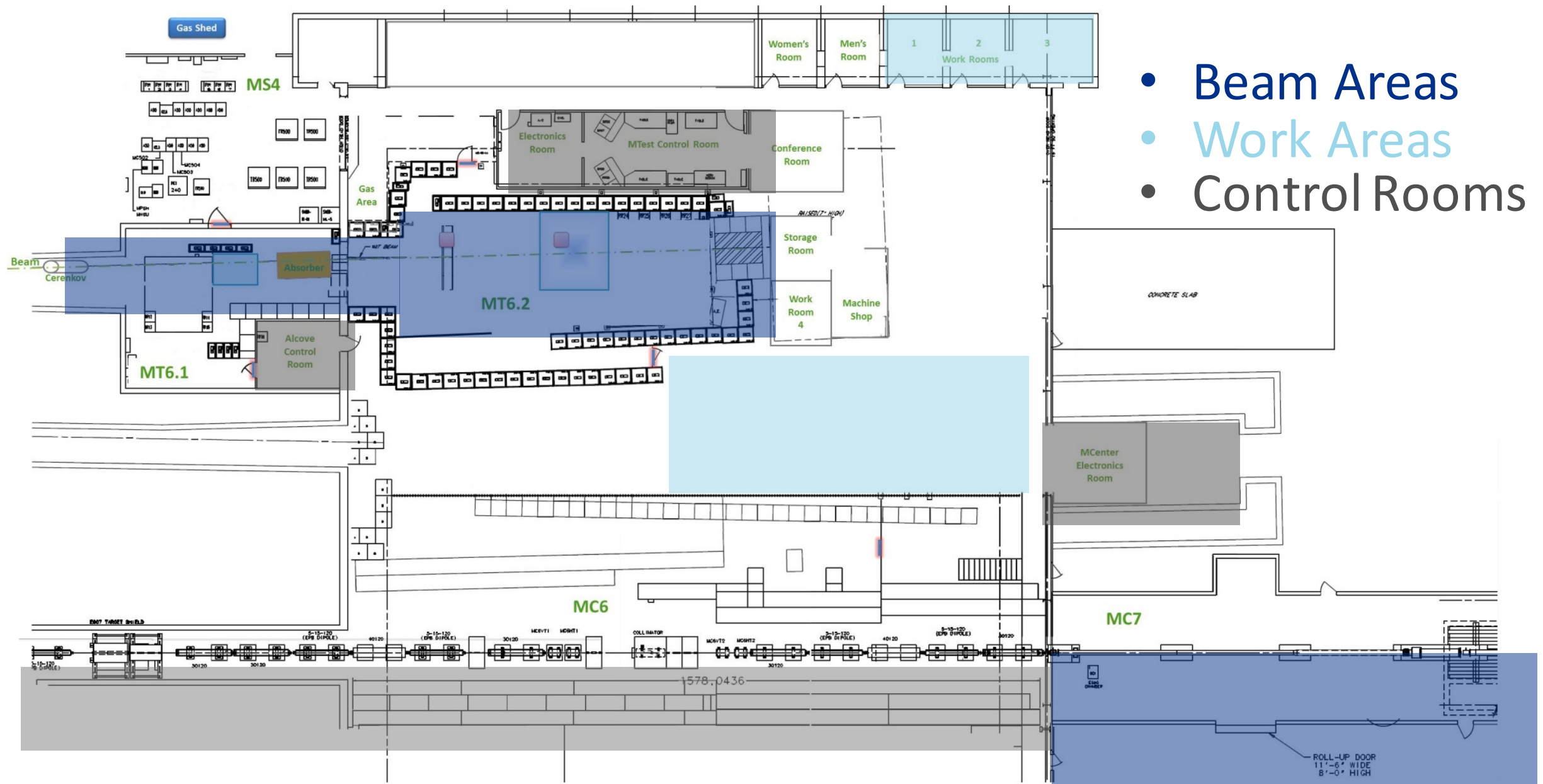


Meson Detector  
Building - West



# FTBF Layout

## MTest Beamline

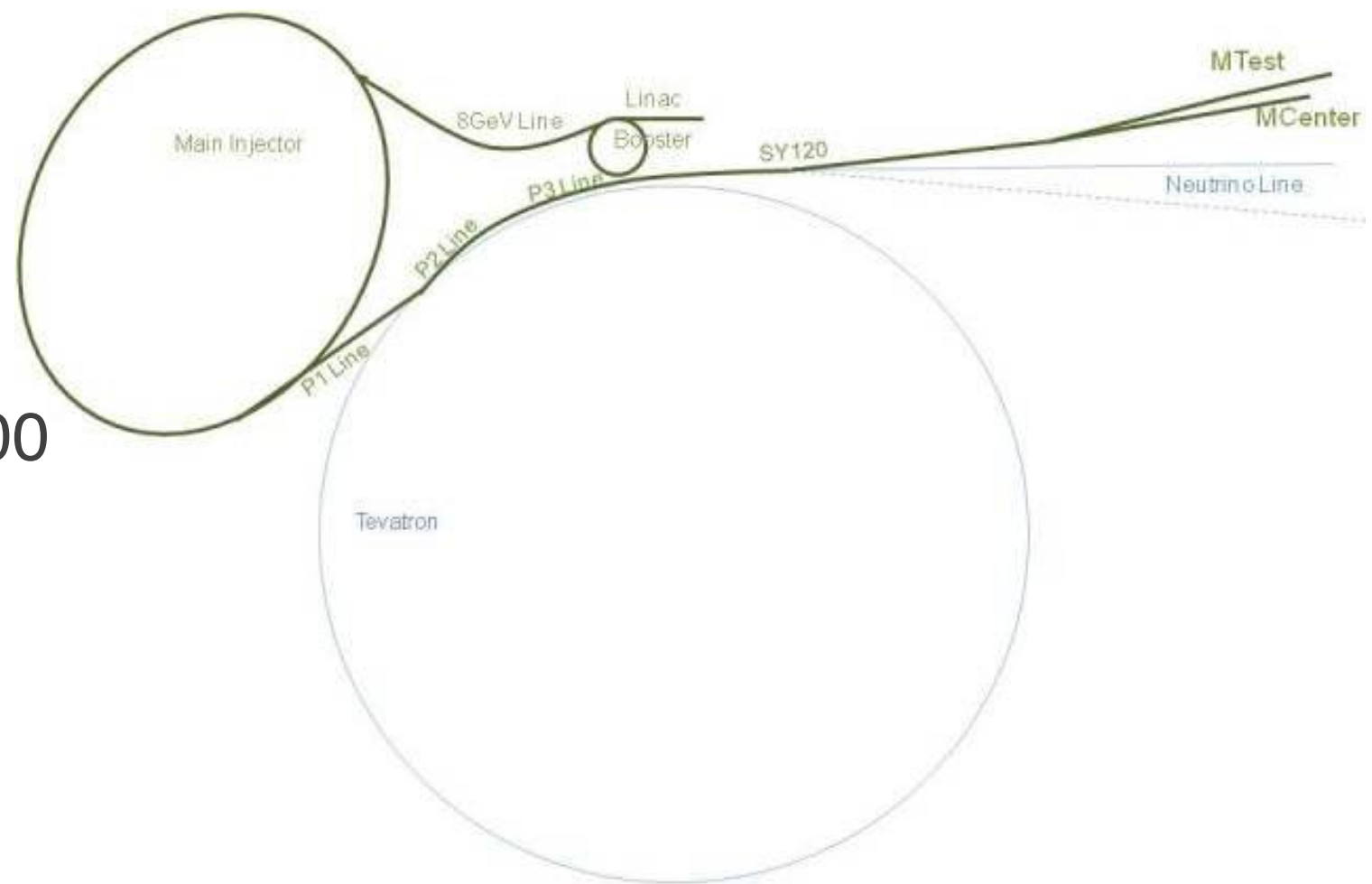


- Beam Areas
- Work Areas
- Control Rooms

## MCenter Beamline

# Beam Details

- 4 second beam spill every 60 seconds, available 24/7
- Tunable rate from 100 to 100,000 Hz
- MTest
  - 120 GeV primary protons
  - 1-66 GeV secondary beam
  - ~2cm spot size
- MCenter
  - Two tertiary beamlines down to 200 MeV
  - One area with cryogenic support, previously used by LArIAT
  - New tertiary beam being commissioned now for NOvA



Thanks to AD operators for securing enclosures and working with each group to deliver beam!

Coordination and support from Ext. Beams dept: T. Kobilarcik, J. St. John, A. Watts, G. Koizumi, P. Allcorn

<https://ftbf.fnal.gov/beam-overview/>



# Beam Performance - MTest

## Positive Beams Composition, Open Collimators 2016

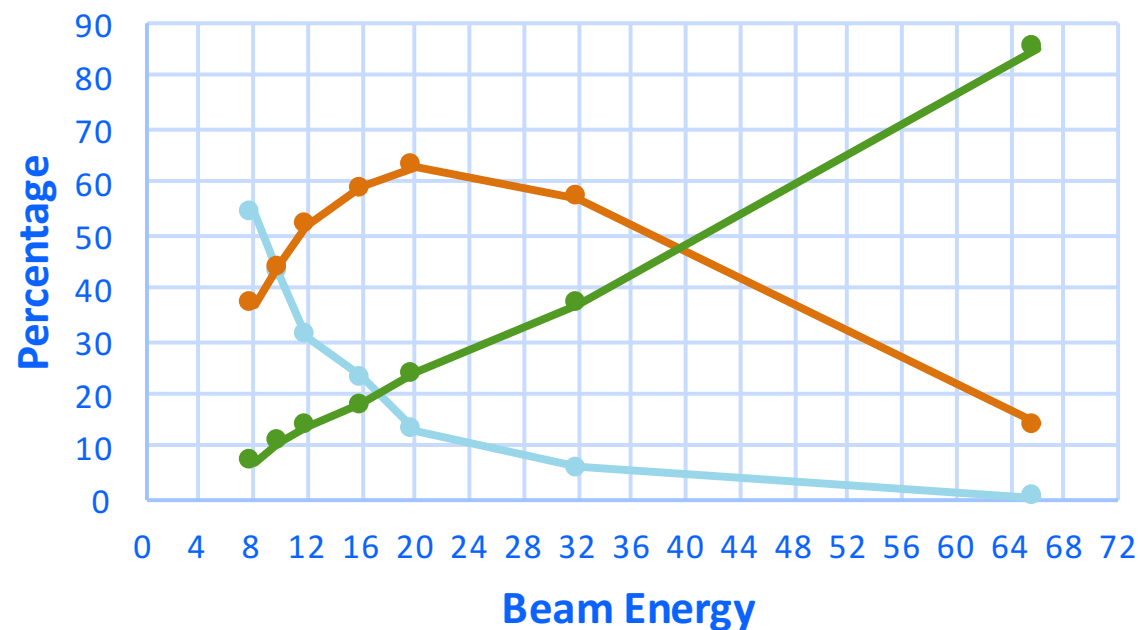
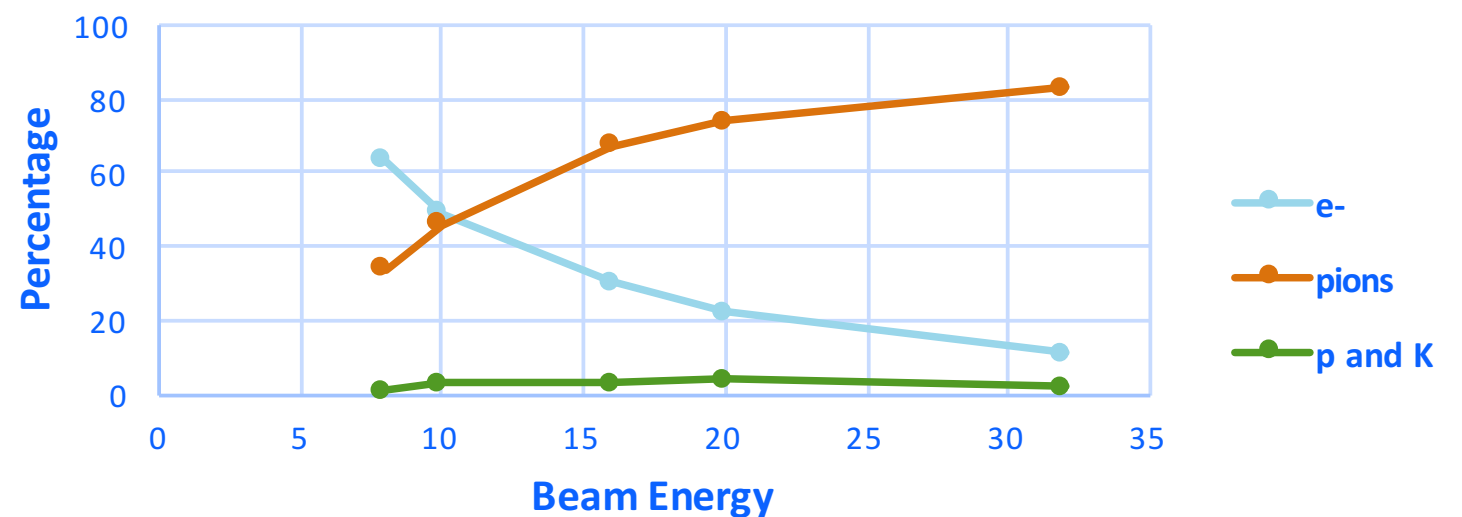


Table with energies, beam spread, percentages:  
<http://ftbf.fnal.gov/mtest-beam-details-2/>

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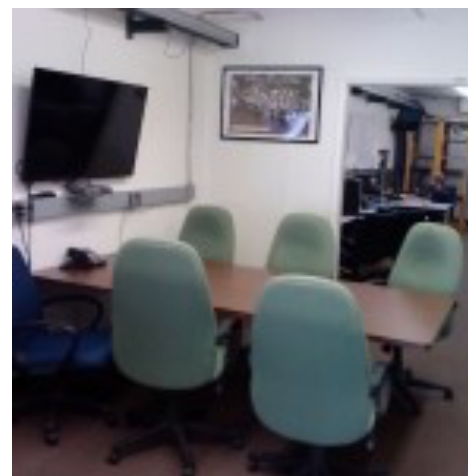
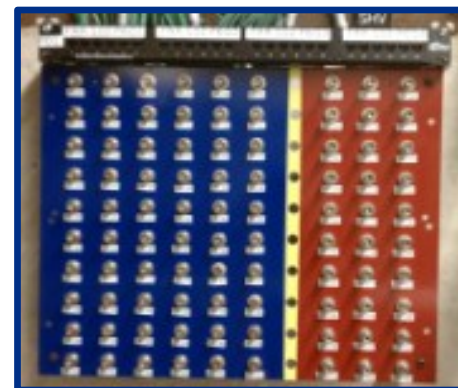
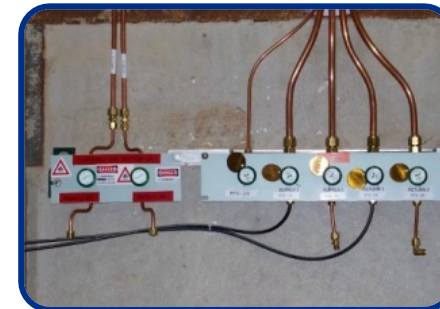
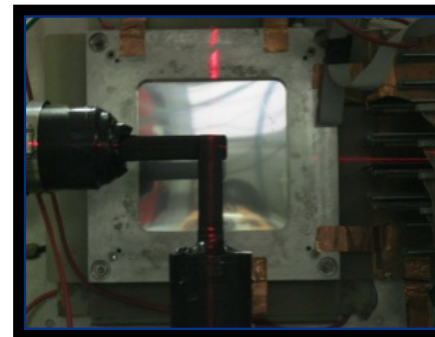
Studies by E. Skup and D. Jensen

## Negative Beams Composition, Open Collimators 2016



# Facility Infrastructure

- ACNET controlled motion tables
- Laser alignment
- Helium tubes
- Web based cameras
- Crane coverage (30 ton)
- climate controlled huts
- Gas patch panels
- Signal, network, HV panels
- Two control rooms
- Counting house
- Machine shop
- Technical staff to help turn any plan into reality

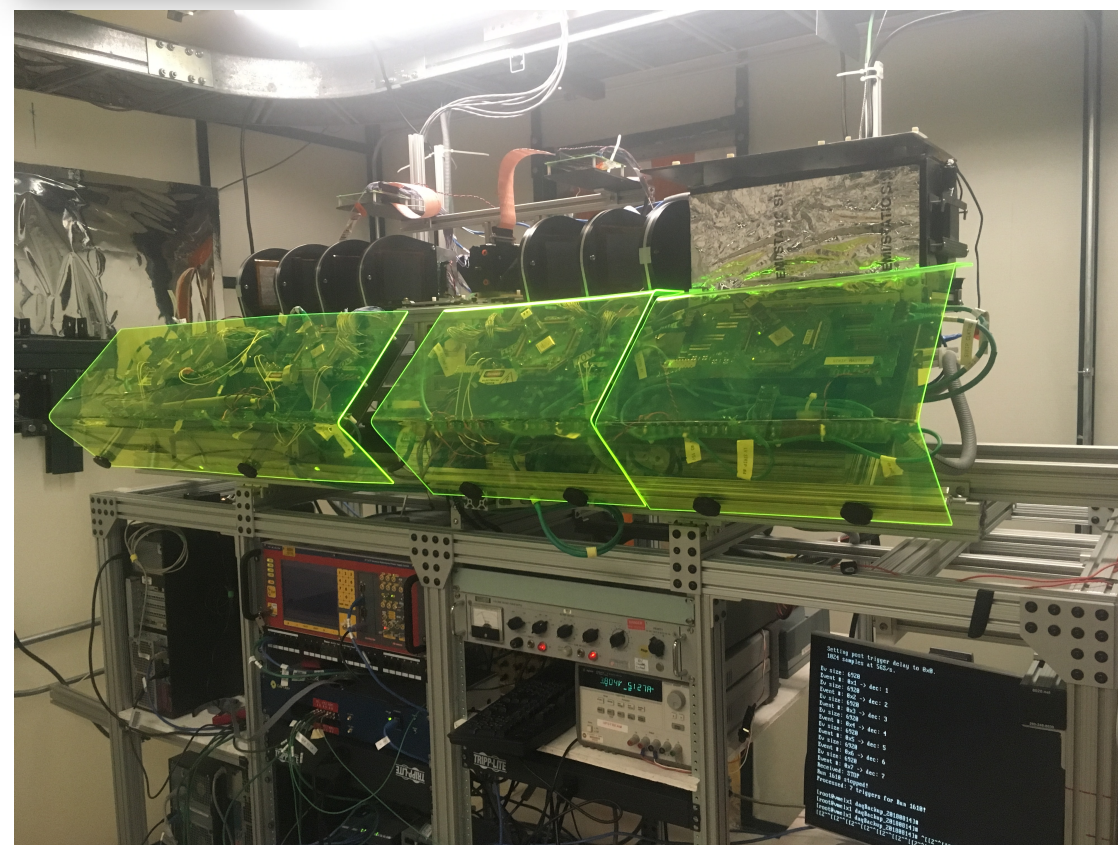
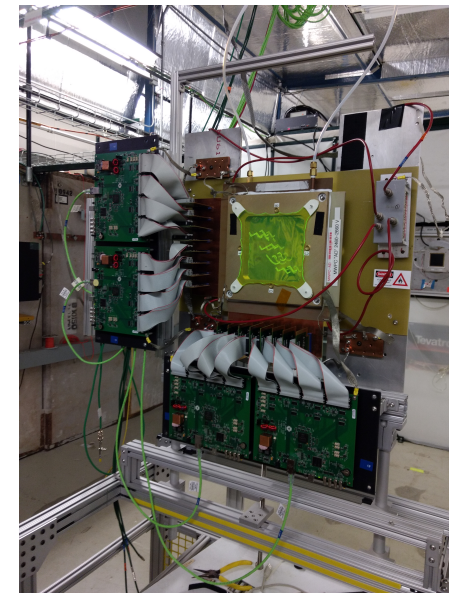
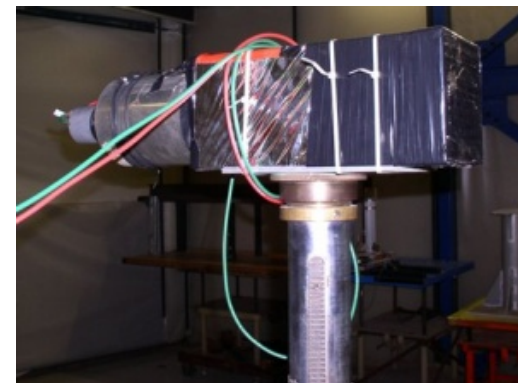
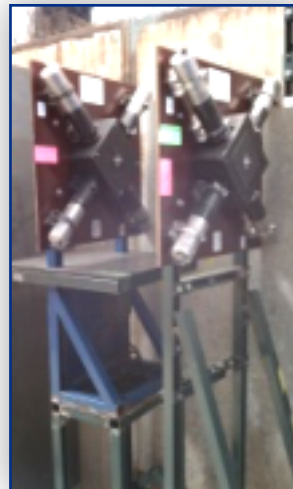
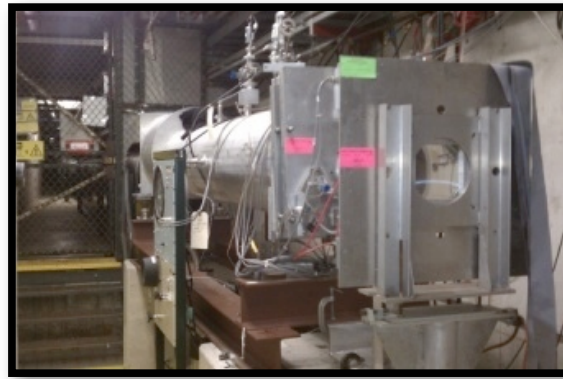




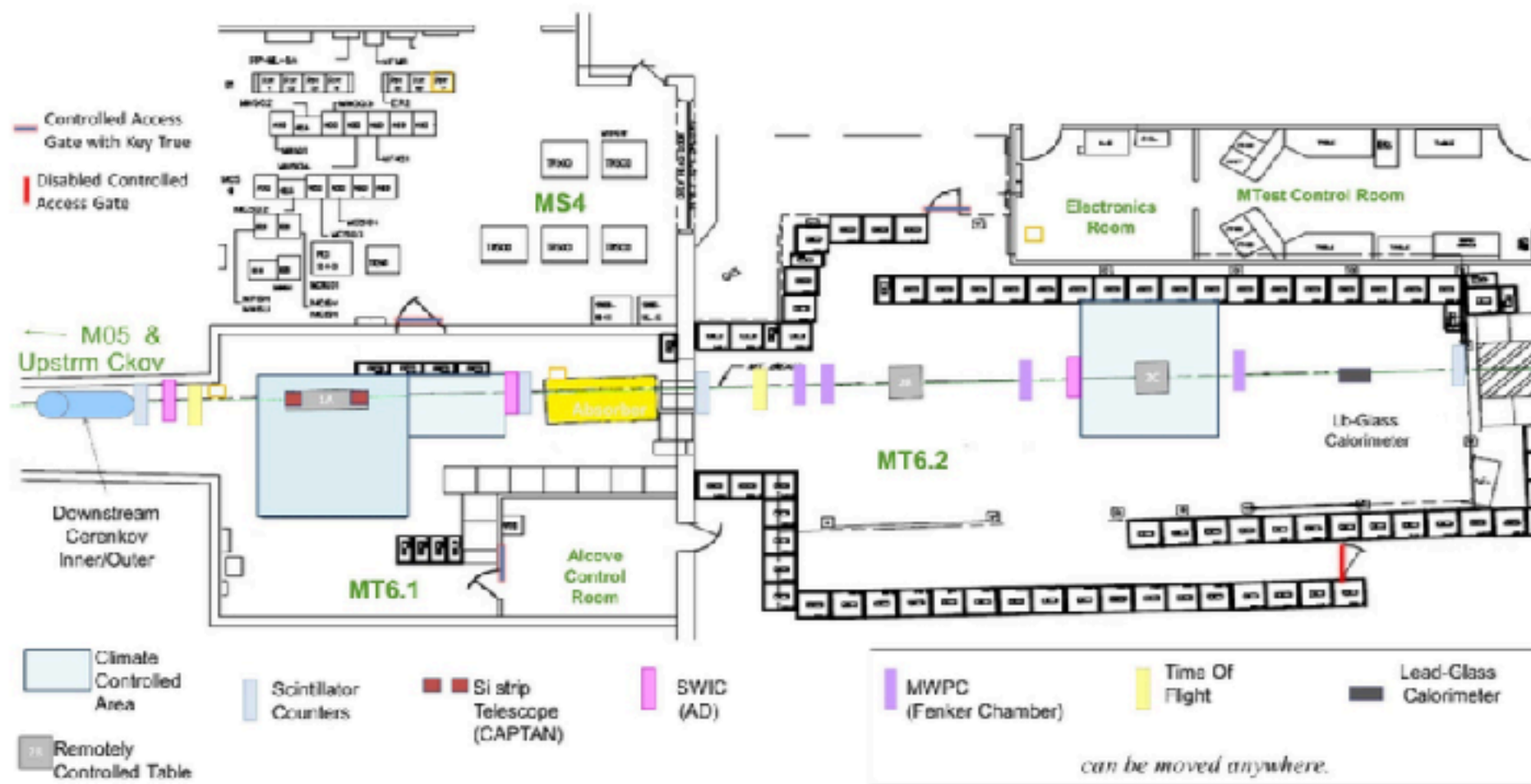
# Facility Instrumentation

- Cherenkov detectors
- Multi Wire Proportional Chambers
- Lead glass calorimeter
- Assorted scintillator paddles
- Silicon strip and pixel telescope

<https://ftbf.fnal.gov/instrumentation-overview/>

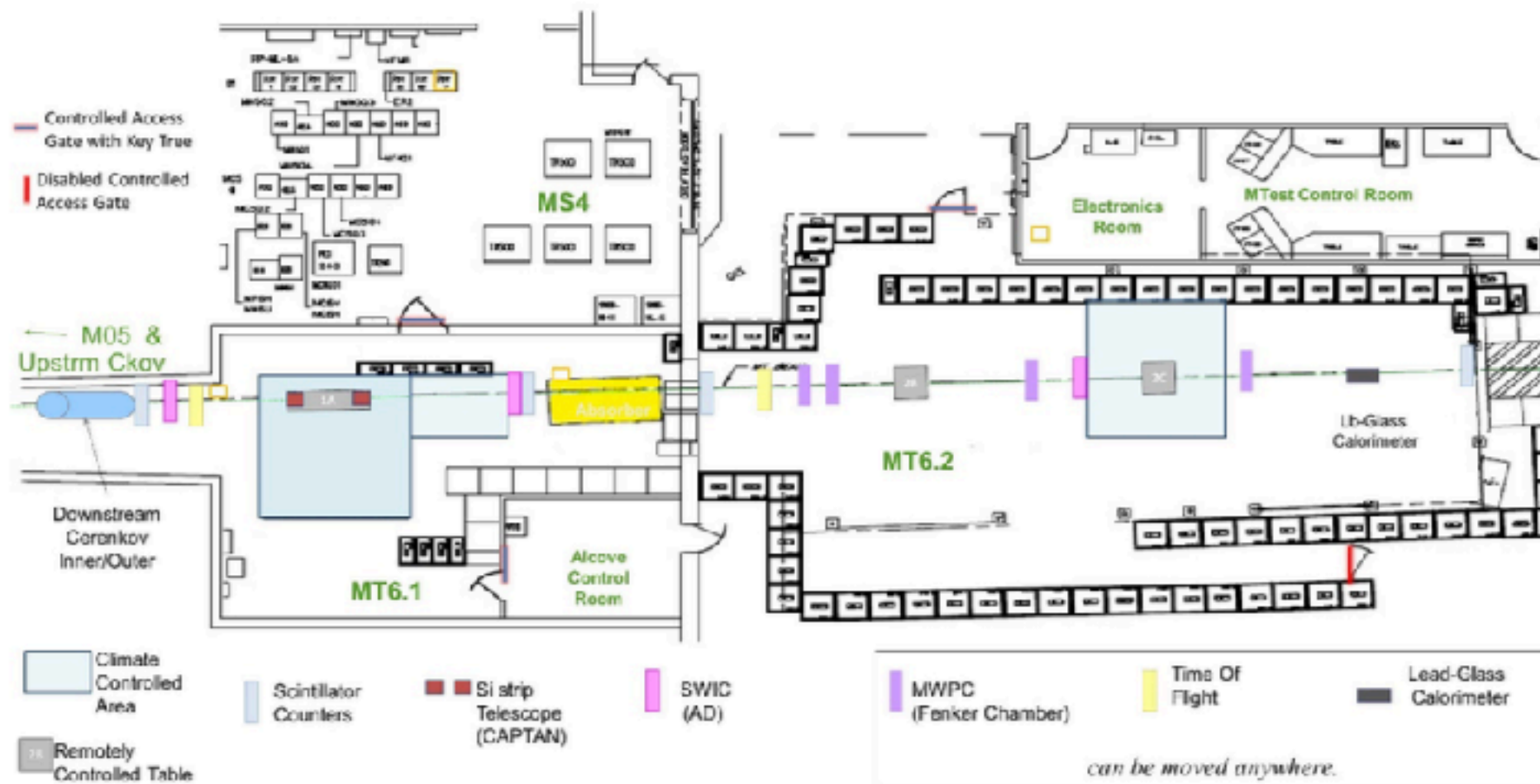
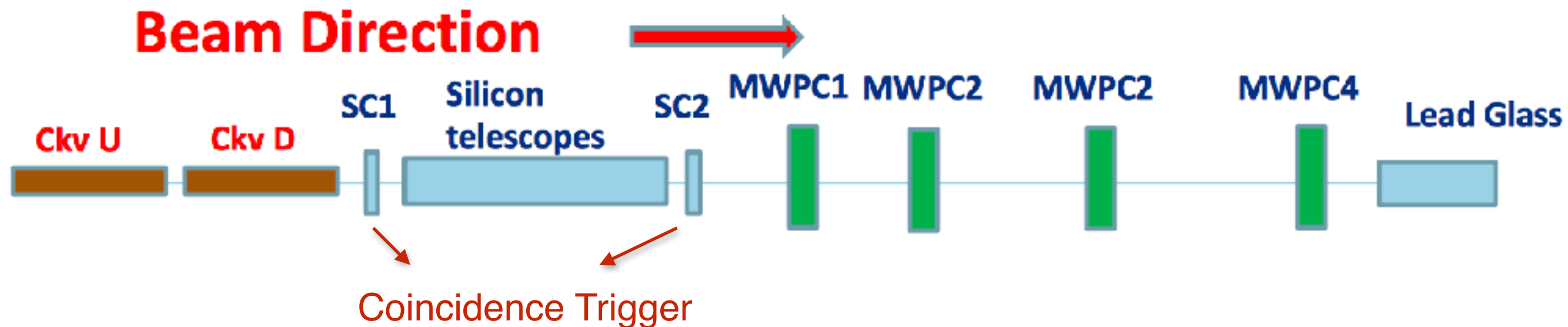


# Instrumentation Layout



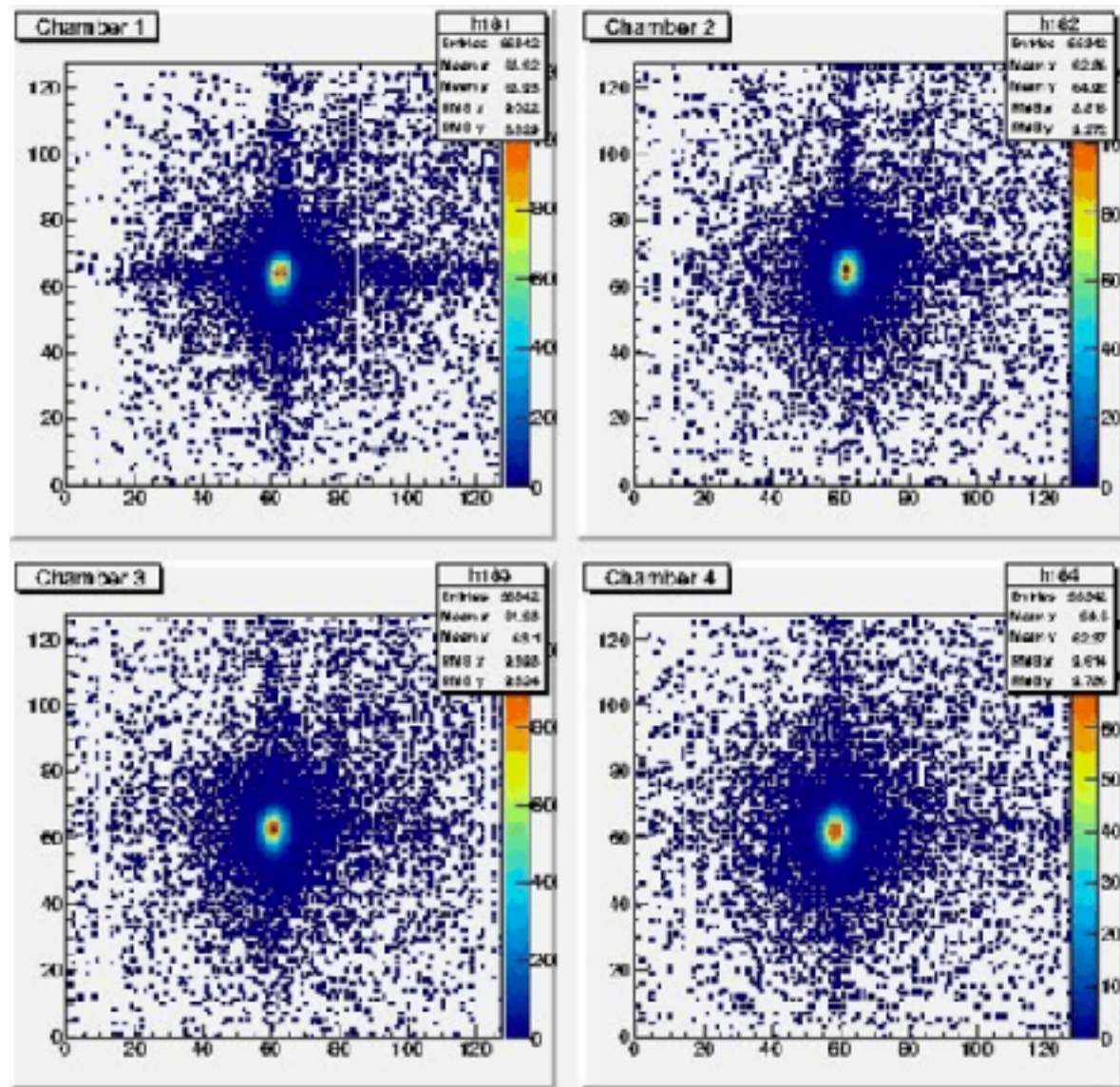
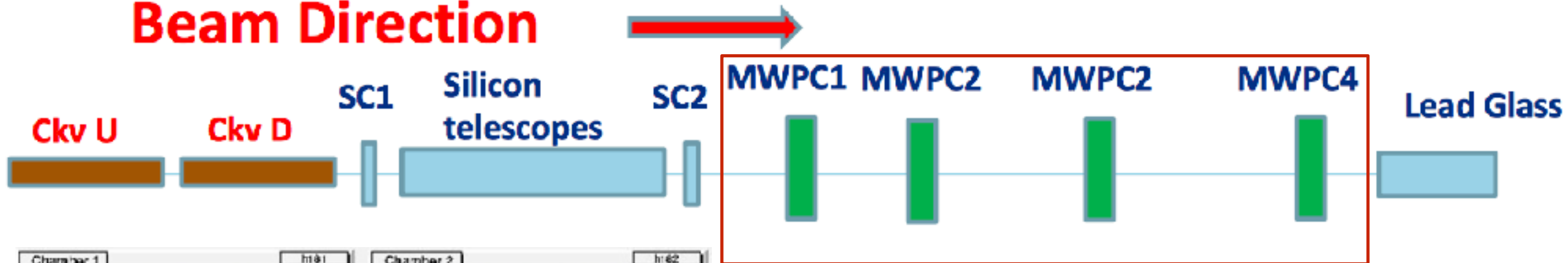


# Instrumentation Layout

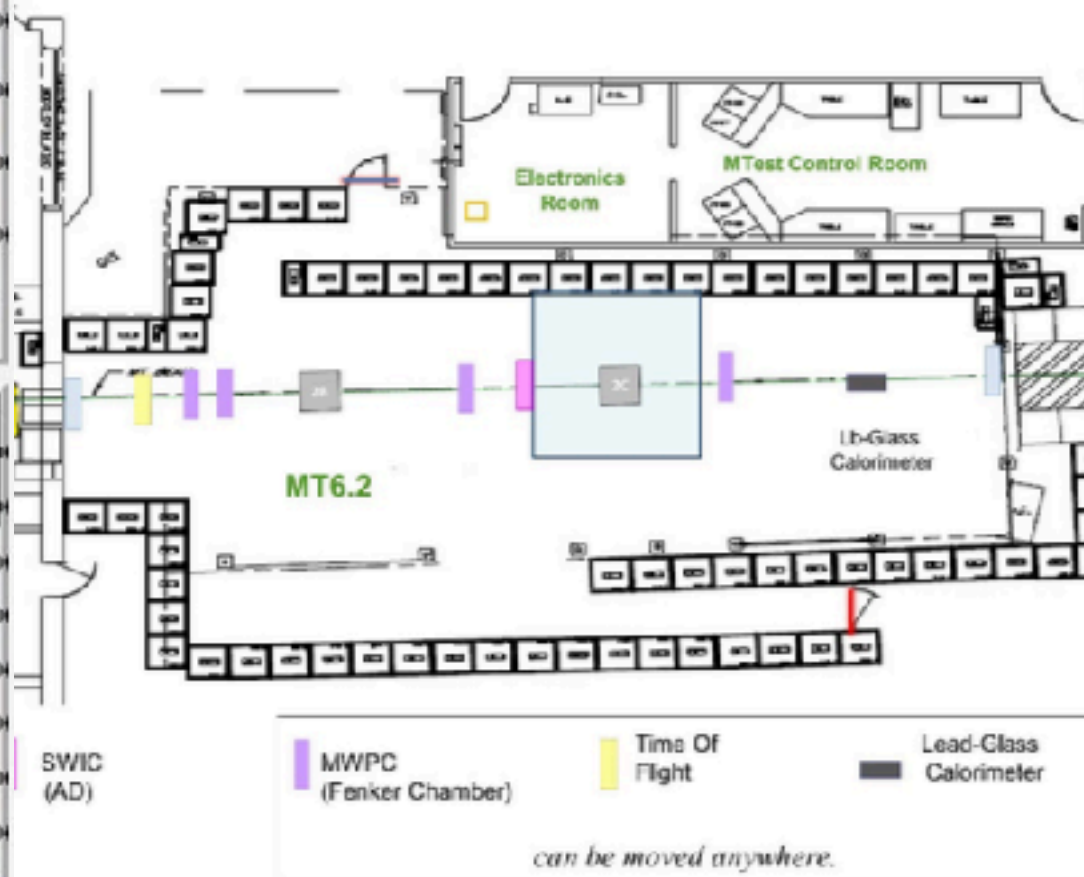


# Instrumentation Layout

## Beam Direction



Tracking



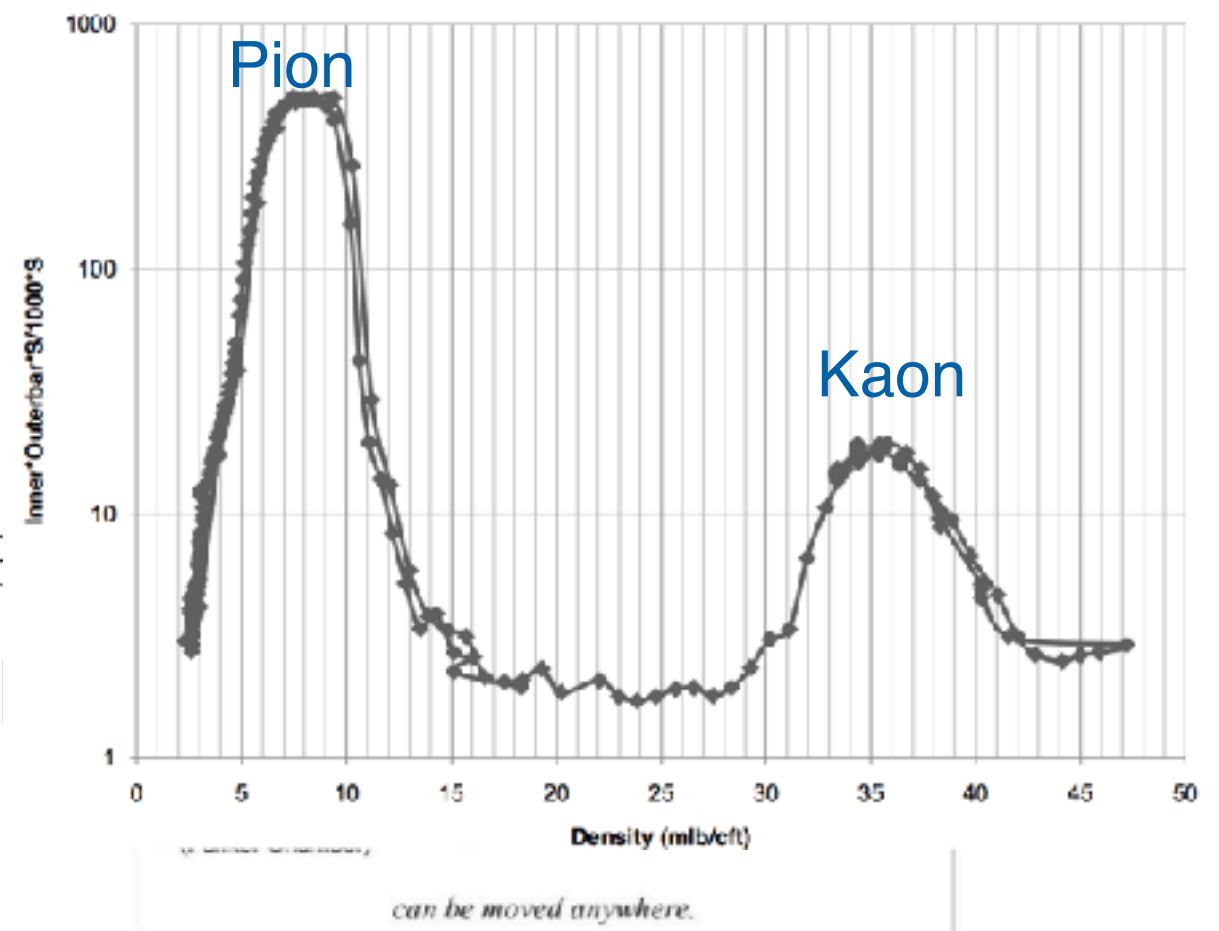
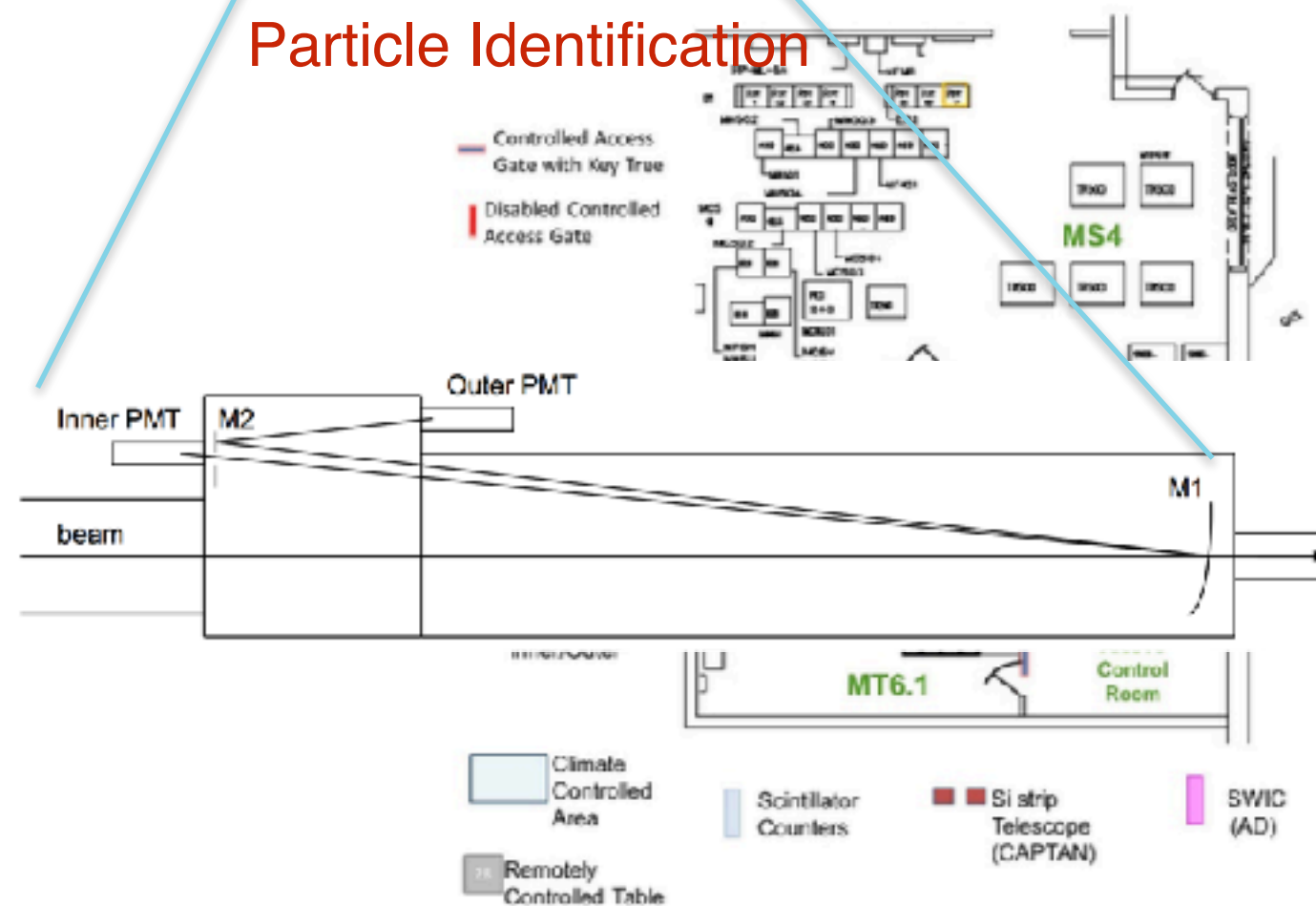
# Instrumentation Layout

## Beam Direction



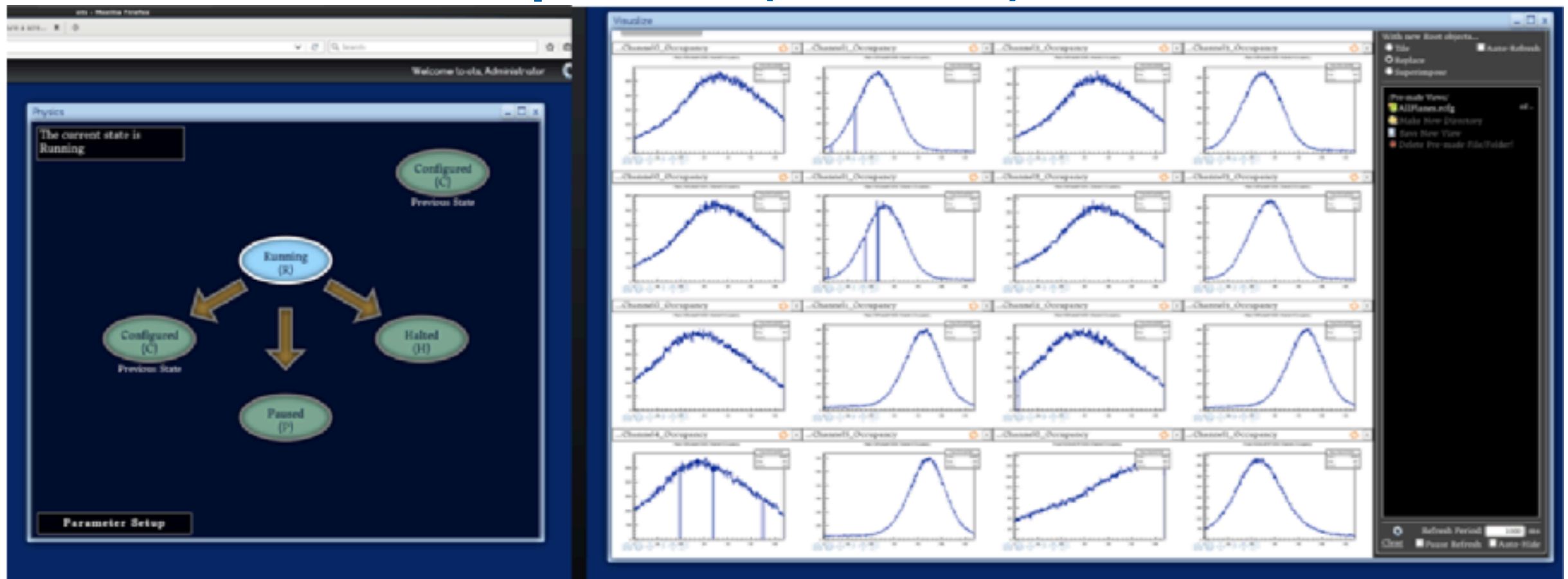
Fig. 9. 32 GeV/C Density Curve after Mirror Alignment

## Particle Identification





# Off-The-Shelf Data Acquisition (OTSDAQ)



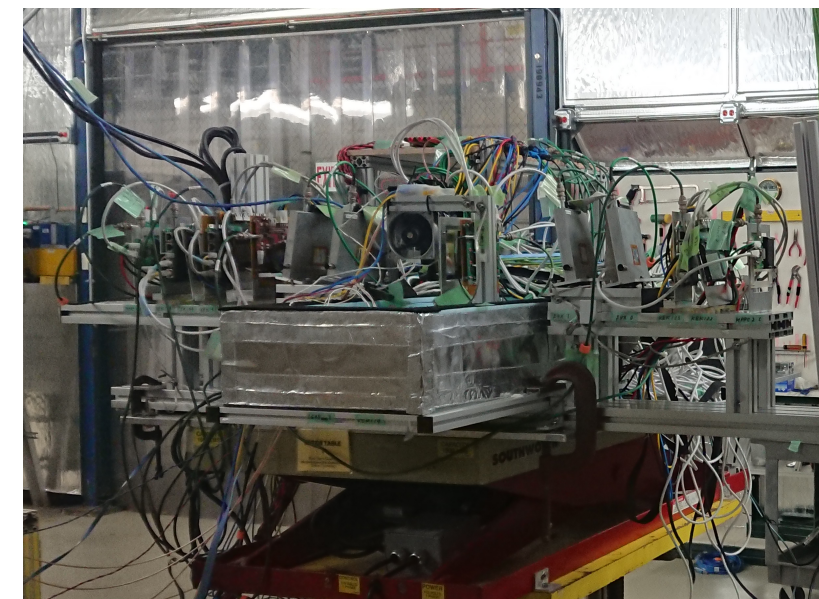
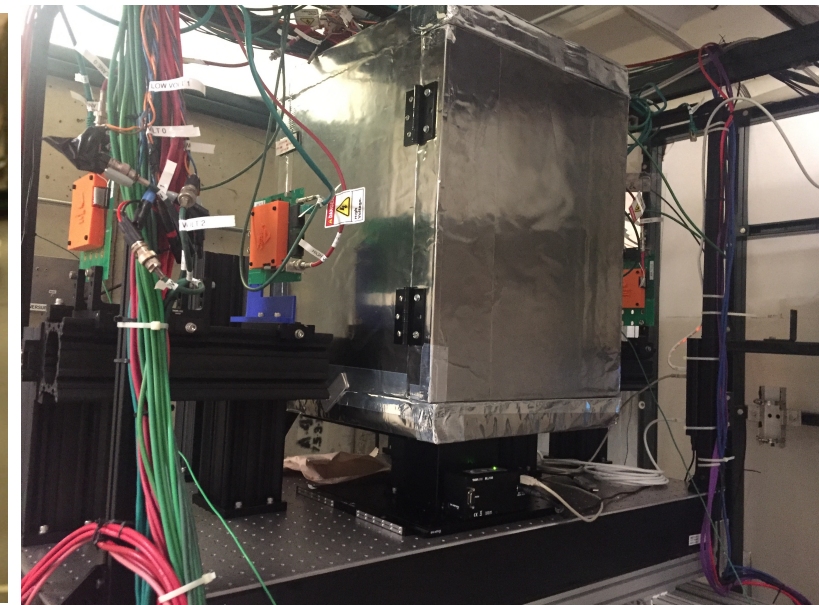
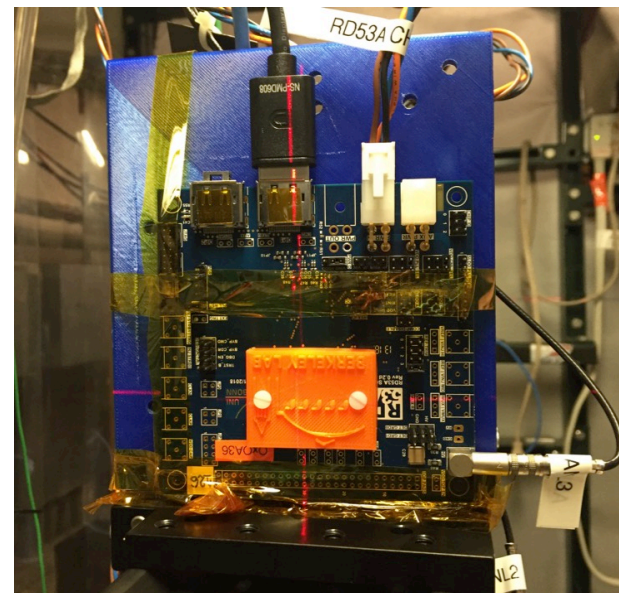
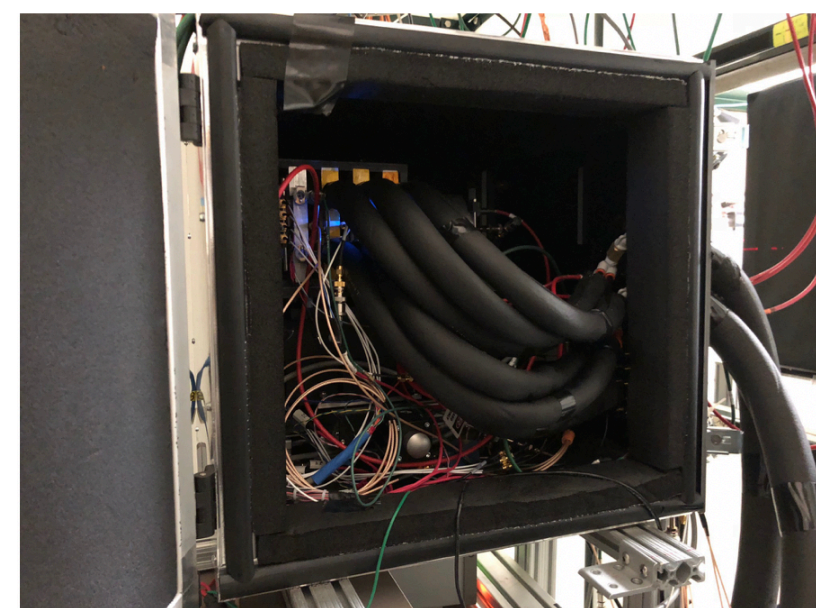
- SCD developed, flexible and scalable system allowing integration with other devices
- Tied into facility MWPCs, Cherenkov detectors, silicon strip telescope.
- Working to integrate with facility, enhance user experience, document
- Several groups (CMS outer tracking, CMS Timing, RD53 chip) have integrated and taken fully synchronized data with the telescope

L. Uplegger, R. Rivera, E. Flumerfelt

<http://otsdaq.fnal.gov/>

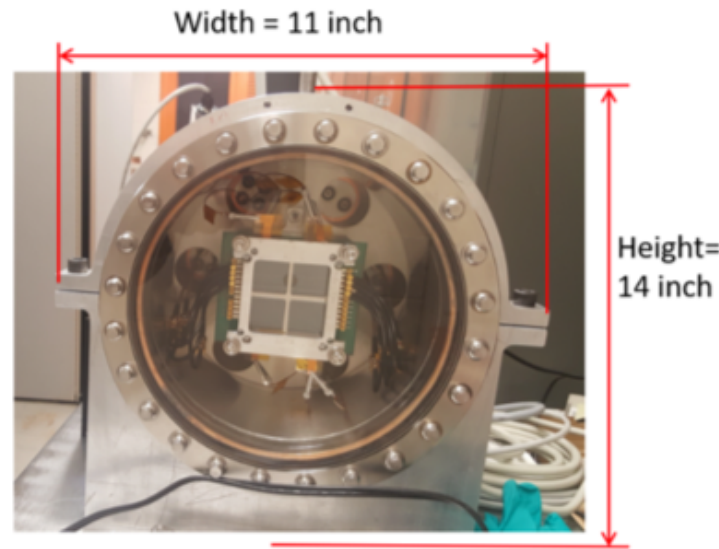
# LHC Groups

- CMS (T992, T1409, T1516), ATLAS (T1068, T1224), LHCb (T1564)
- High Luminosity LHC upgrade R&D
- Variety of sensor and readout chip (RD53a) testing.
  - Both before and after irradiation
- Radiation hard timing detectors with 30-40 picosecond resolution
- Telescope development and testing

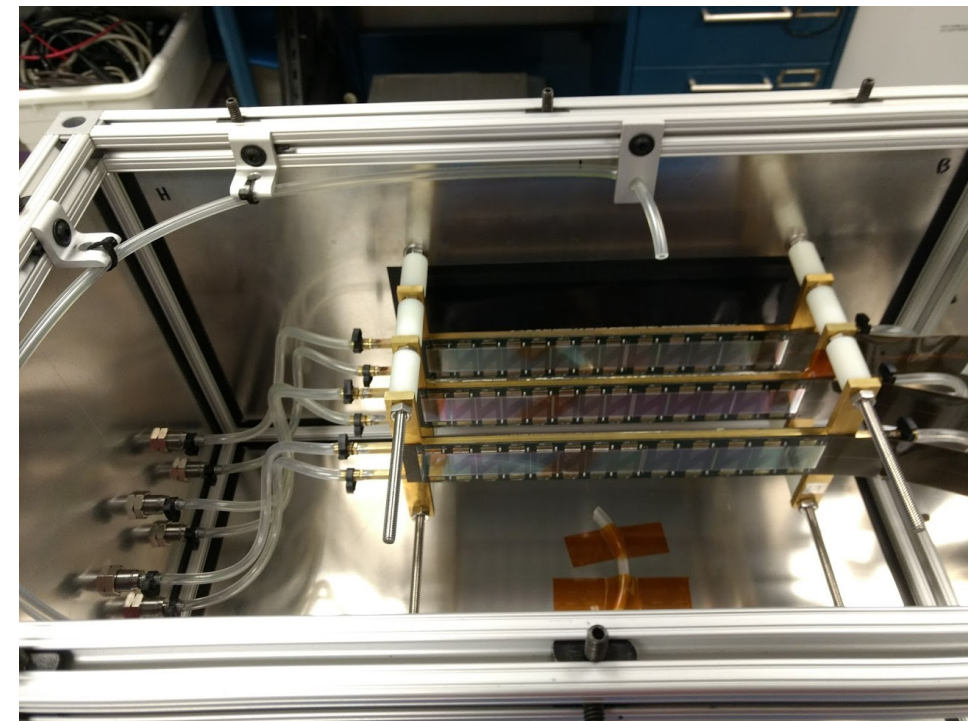




## Other Collider Efforts



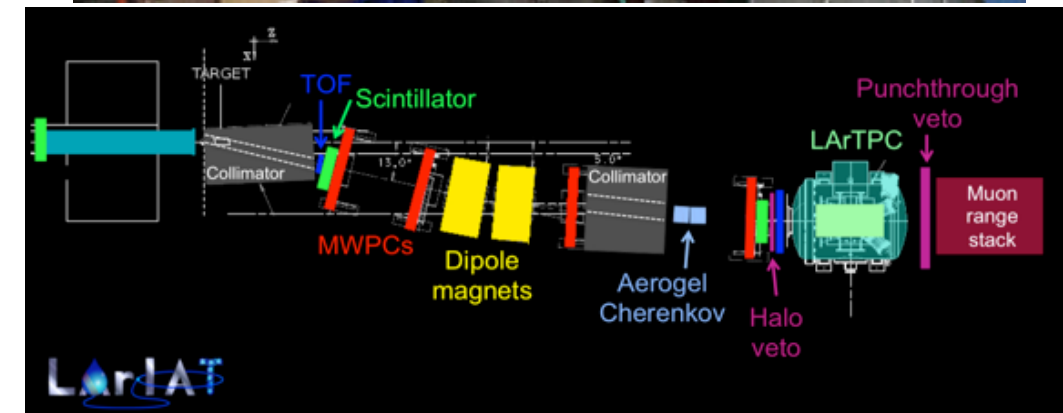
- Electron Ion Collider (EIC) and sPHENIX detector R&D
- T1429, T1439, T1441, T1450, T1473, T1564
- Calorimeters, trackers, vertex detectors, TPCs, GEM and Micromegas
- Ongoing program testing options. Component integration and DAQ testing





# Neutrinos

- LArIAT
  - Tertiary beam in MC7a
  - Liquid argon detector, installed cryogenics
  - technology R&D (light collection, cold electronics, pixel readout, etc)
  - Measure hadronic cross sections in liquid argon
- EMPHATIC
  - Measure hadron production to constrain flux for neutrino experiments
- MINERvA
  - Measure detector energy response to hadrons
  - DAQ testing





# Neutrinos

- New tertiary beam installed in MC7B
- NOvA test beam installing and commissioning
- Data collection in FY20

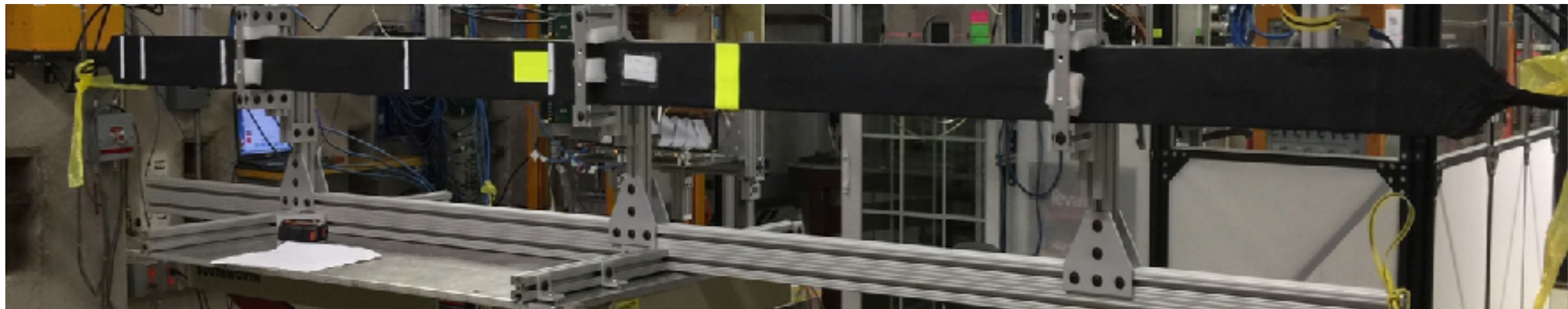
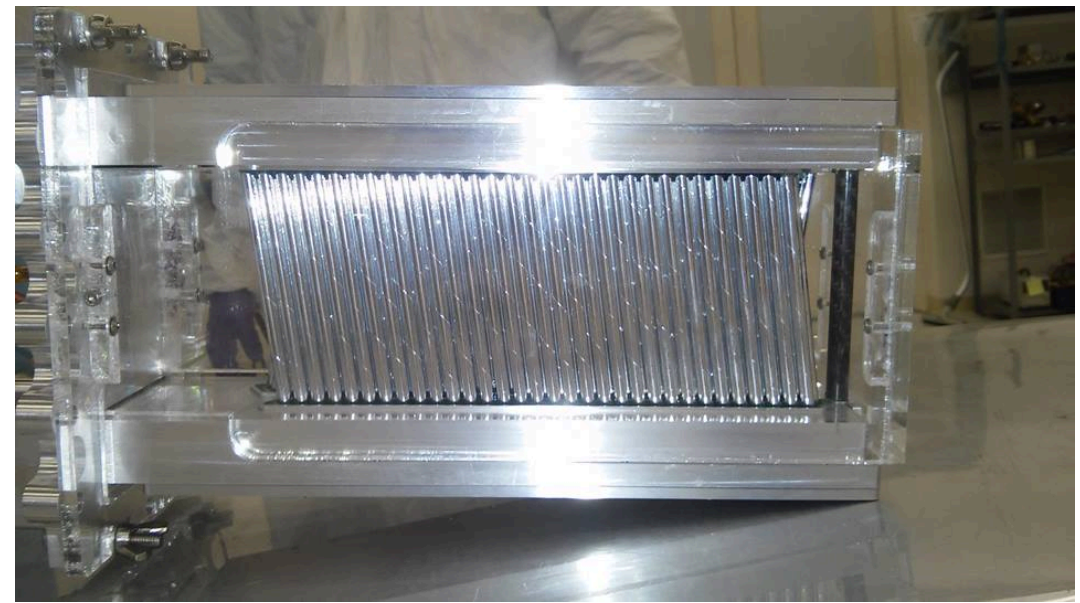


Photo courtesy A. Sousa



# Muons

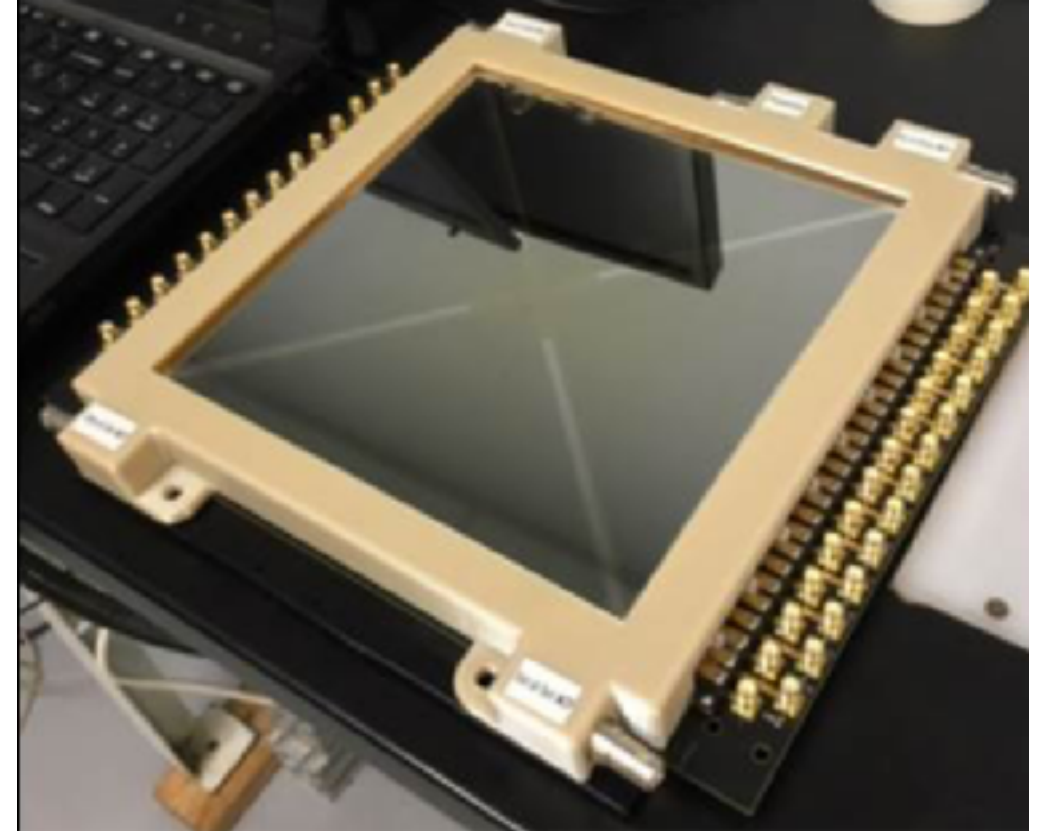
- g-2 straw tracker
  - tested full readout electronics chain
  - tested various gas mixtures
  - performing great in experiment
- Mu2e cosmic ray veto
  - Measured photoelectron yield in scintillator counters
- Mu2e straw tracker
  - came briefly, determined HV issues





## General R&D

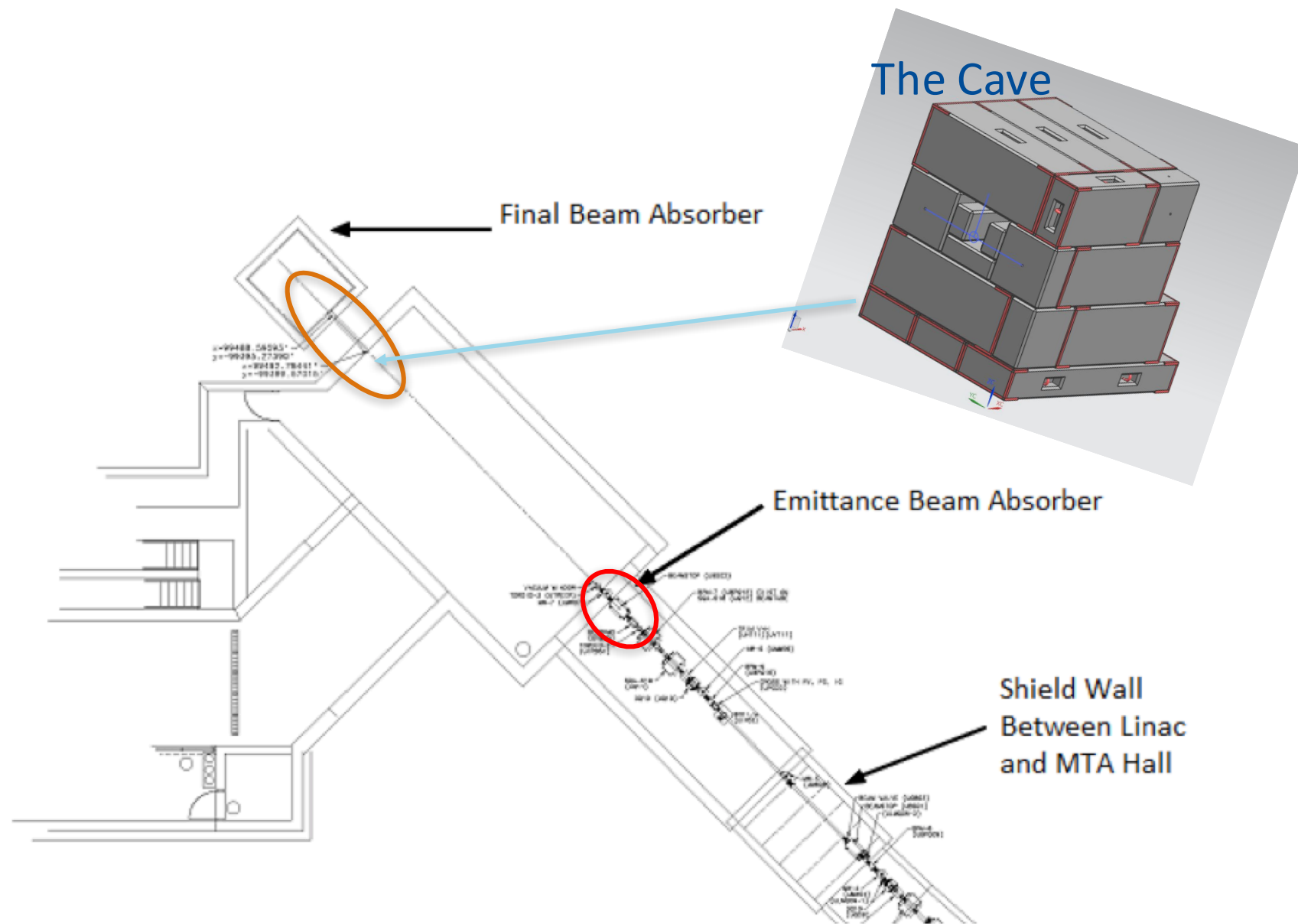
- Many groups come for general purpose R&D
- Characterizing properties of Large-area Picosecond Photo Detectors (LAPPD<sup>TM</sup>) for use in a time-of-flight system
- Experiment built and operated by one U. Chicago graduate student (E. Angelico)





# Irradiation Test Area

- Large demand for on-site facility to irradiate sensors
- Hand-in-hand with testing at FTBF
- MTA area being cleared out before construction
- Goal to be available early 2020





# Irradiation Test Area

**Before**



**After**

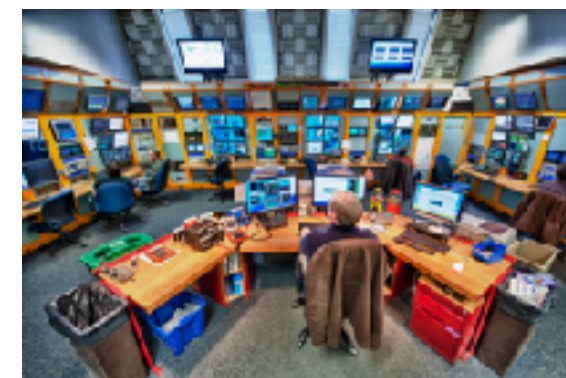
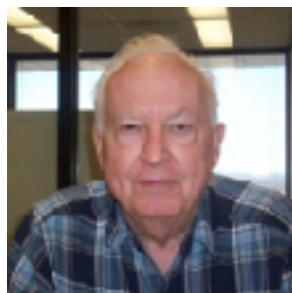
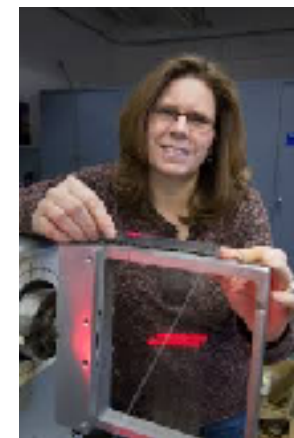
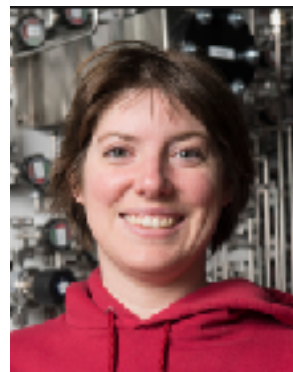


MTA space largely cleared out

Photos courtesy J. St. John



# It takes a village



# Summary

- FTBF is a world class facility for detector R&D
- Continually improving facility resources and the user experience
- Great training bed for students
- Scheduling FY20 beam time soon. If you have a project in mind we are dedicated to making it happen!
- Learn more
  - FTBF [elog](#)
  - Slack Team: [fnal-testbeam](#)
  - Webpage: [ftbf.fnal.gov](#)
  - Listserv: [test\\_beam@fnal.gov](mailto:test_beam@fnal.gov)